The preparation and attitudes of calculus-based Physics 227 and algebra-based Physics 103 students
by Jacqueline Alean Stelzl

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University

Abstract:
The problem of this study was fivefold: (a) to deter- mine sex-related differences in preparation for the study of physics; (b) to determine relationships between preparation for and grades in physics by sex; (c) to determine sex-related differences in attitudes toward physics; (d) to determine relationships between attitudes toward physics and grades in physics by sex; and (e) to compare the attitudes of science and engineering students to those of nonscience and nonengineering students toward phy si cs by sex.

This investigation was carried out in the following manner. A survey was distributed to students in Physics 227 and 103 at Montana State University during the winter quarter of 1981. The survey instrument was a modified version of the Fennema-Sherman Mathematics Attitudes Scales. The scales were modified to pertain to the study of physics rather than mathematics. Letter grades assigned after completion of the course were compared to survey responses. Data were analyzed using the Pearson-product-moment correlation coefficient and a t test of significance between the means. Hypotheses were tested at the 0.05 level.

Each of the following math and science preparation, was found to be correlated to grades in physics for some groups: the number of years of high school math, science, and physics; and the number of quarter hours of college math. The following attitudes were correlated to grades in physics for some groups: positive attitudes toward women in physics; confidence; low anxiety; the perceived usefulness of physics; and the active enjoyment of physics. Some significant differences were found between the math preparation, science preparation, and attitudes of males as compared to those of females. Also, a few significant differences were found between the attitudes of Physics 227 students as compared to those of Physics 103 students.

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by

Jacqueline Alean Stelzl

A thesis submitted in partial fulfillment
of the requirements for the degree

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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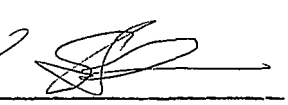
Signature 

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ABSTRACT

The problem of this study was fivefold: (a) to determine sex-related differences in preparation for the study of physics; (b) to determine relationships between preparation for and grades in physics by sex; (c) to determine sex-related differences in attitudes toward physics; (d) to determine relationships between attitudes toward physics and grades in physics by sex; and (e) to compare the attitudes of science and engineering students to those of nonscience and nonengineering students toward physics by sex.

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Each of the following math and science preparation was found to be correlated to grades in physics for some groups: the number of years of high school math, science, and physics; and the number of quarter hours of college math. The following attitudes were correlated to grades in physics for some groups: positive attitudes toward women in physics; confidence; low anxiety; the perceived usefulness of physics; and the active enjoyment of physics. Some significant differences were found between the math preparation, science preparation, and attitudes of males as compared to those of females. Also, a few significant differences were found between the attitudes of Physics 227 students as compared to those of Physics 103 students.

It is noteworthy that some attitudes which this study indicated as significantly affecting one's grades in physics were also found to be sex dependent. Thus, instructors should examine their teaching methods to ensure that they are not discouraging capable students from this discipline.

Chapter I

INTRODUCTION

Traditionally, because physics has been considered to be a man's field, more men than women have selected physics as an occupational field and so the great majority of students who choose to major in this discipline today are male.

In 1978-79, for example, only 12.8% of physics bachelor's degrees were awarded to women (AIP Report, 1980). Such a disparate representation of men and women may reflect sex-related differences in ability for, preparation for, or attitudes toward physics. This study examined the latter two of these possibilities. It did not attempt to examine one's innate ability to do physics, although there is some evidence in the research literature to suggest that physiological differences may partially account for sex-related differences.

Since math and science are part of one's preparation for study in physics, how much does this preparation affect physics grades in college? Brasted (1975) found the taking of high school science to affect performance in college chemistry. Certain implications might also arise regarding

the sex of the student if females are not equally encouraged with males to take math and science in high school. Research such as that by Haven (1970), shows that male and female students do not always receive the same amount of math and science as part of their high school education. Males may be encouraged to take much more math and science. If women are discouraged from participating in math and science, then lack of knowledge in these areas will affect their lives. According to the report "A Nation at Risk. The Imperative for Educational Reform," (released by the National Commission on Excellence in Education, 1983) people who are lacking in such skills and training will become disenfranchised. Whatever barriers keep women from math related careers must be removed. For example, math anxiety among women can have serious effects. This is also true for men. Math anxiety may cause those who are math-anxious to become math-avoiders (Morris, 1981). Morris goes on to say that math avoidance was tolerable when many jobs required little mathematics, but today, those who avoid math become isolated from full participation in a technological society.

Attitudes toward physics, which may be generally described as one's perceptions of the subject-matter field, are important for study in physics. An individual's perception of himself or herself may also influence the career choices that one makes. Influencing these choices

may be: attitudes toward success in physics, the perceived masculinity of physics, attitudes toward one's ability to do physics, the perceived usefulness of physics, feelings of anxiety, and the active enjoyment of physics. Extensive research on sex-related attitudes has been conducted by Fennema and Sherman (1977) and by Fox (1979). Although their work did not pertain to physics directly, it examined a closely related discipline, mathematics, a field which carries many of its principles over into physics.

If women are underrepresented in physics because they lack the preparation necessary to pursue this field, then women should be more strongly advised to take these courses early in their academic studies. Women may be less well prepared than men for study in physics, and their performance in college physics may be greatly hindered by deficient preparation. Similarily, if it appears that certain negative attitudes affect academic performance, then instructional stategies could be used to change some of these attitudes. In short, women should have the same opportunity that men have to pursue their interests in the field.

Statement of the Problem

The problem of this study was fivefold: (a) to determine sex-related differences in preparation for the

study of physics; (b) to determine relationships between preparation for and grades in physics by sex; (c) to determine sex-related differences in attitudes toward physics; (d) to determine relationships between attitudes toward physics and grades in physics by sex; and (e) to compare attitudes toward physics by sex of science and engineering students to those of nonscience and nonengineering students enrolled in physics during the 1981 school year.

Application

The results of this study can be used for student advisement and for the improvement of instructional strategies. If it can be determined what preparation is most advantageous for high achievement in physics, then counselors could use the information for student advisement especially at the high school level. With the proper advisement, students could be made aware of their deficiencies prior to enrolling in physics. Curricula could be planned to encourage those attitudes which significantly affect one's success in physics. Instructional strategies could be devised to moderate or correct negative attitudes. As preparation for and attitudes toward physics improve, grades might improve.

General Questions

The following questions were examined:

1. What are the relationships between grades in physics and the following subcategories of preparation for physics:

(a) The number of years of high school math,

(b) The number of years of high school science,

(c) The number of years of high school physics,

(d) The number of quarter hours of college math,

(e) The number of quarter hours of college science,

(f) The number of quarter hours of college physics prior to the present physics course?

2. How does the amount of math and science preparation of males compare to that of females?

3. What are the relationships between grades in physics and the following subcategories of attitudes:

(a) Attitudes toward success in physics,

(b) The perceived masculinity of physics,

(c) Attitudes toward one's own ability to do physics,

(d) The perceived usefulness of physics,

(e) Feelings of anxiety toward physics,

(f) The active enjoyment of physics?

4. How do the attitudes of males compare to those of females?

5. How do attitudes of science and engineering students compare to attitudes of other students?

Several outcomes were predicted.

A. It was expected that the more math and science taken by an individual prior to college physics, the better will be his or her performance in college physics.

B. Males were expected to have a better preparation in math and science than females.

C. Positive attitudes toward success in physics, one's own ability to do physics, the perceived usefulness of physics, and the active enjoyment of physics were expected to have a positive effect on academic performance. Feelings of fear toward physics are expected to negatively affect one's academic performance. The perception of physics as a masculine field was expected to negatively affect the academic performance of females but not of males.

D. The attitudes of males were expected to be different from the attitudes of females.

E. The attitudes of science and engineering students were expected to be more positive than the attitudes of other students.

General Procedure

These research questions were approached in the following manner. A questionnaire was distributed about the second week of the winter quarter of 1981 to all students in Physics 227 (a calculus-based course designed for science and engineering majors) and Physics 103 (an algebra-based course designed for nonscience and nonengineering majors) at MSU. Responses were returned approximately one to two weeks after they had been distributed. The survey was constructed to obtain information about the students' personal backgrounds, prior coursework in math and science, and attitudes toward physics. Grades were obtained from the class role at the end of the quarter. Student signatures on the survey instrument gave me the authority to obtain this information.

Limitations and Delimitations

This study was limited first of all, by the data collected. The survey relies upon the individual as the source of the data. It is assumed that all responses were accurate descriptions of one's background and attitudes. Second, the study was limited by the faculty members who teach Physics 227 and 103. Faculty are assigned to classes

by the Department Chairman. Physics 227 was taught by a different instructor from the instructor who taught Physics 103. Since the survey was distributed only about a week and a half into the winter quarter, it is assumed that any influence of the instructor's personality on the student was minimal. Third, the study was limited by the teaching assistants in the laboratory sections of Physics 227. The laboratory sections of Physics 227 were taught by several teaching assistants. Because of the gender-related nature of this survey and the request for personal attitudes of students upon enrollment in physics, it is also assumed that the personalities of the teaching assistants did not affect answers of the respondents.

The study was delimited by the population to be studied. The class of Physics 227 and that of Physics 103 were chosen as the populations to be examined. Also, the study was delimited by the date, winter quarter, 1981. Also, the study was delimited by the geographic location. Montana State University was chosen as the campus on which to conduct this investigation.

Definition of Terms

Academic performance was determined by letter grades. Letter grades were assigned as follows. Students earning 90% or more of all available points for the quarter were

assigned the grade A. Students earning 80% to 89% of all points were assigned the grade B, those earning 70% to 79% the grade C, those earning 60% to 69% the grade D, and those earning less than 60% the grade F.

Attitudes were defined as a psychological process encompassing previous experience, such that when one approaches a new situation that previous experience influences his behavior in it (Newcomb, 1966).

Instruction was defined as a situation conducive to learning which need not be limited to teaching.

Summary

It is important that women and men have equal opportunities to pursue their personal and vocational interests. Cited literature suggests that there are sex-related differences in preparation for and attitudes toward physics and that these differences may affect academic performance. This investigation attempted to ascertain if students in Physics 227, a course designed for science and engineering majors, are similar to or different from students in Physics 103, a course constructed for nonscience and nonengineering majors. In addition, the responses of males were compared to the responses of females in these same courses. To investigate this problem, a survey was distributed during the winter quarter

of 1981 to students enrolled in these two courses. Information from this study could be used for instructional improvement and student advisement.

Chapter II

THE REVIEW OF LITERATURE

The review of literature is divided into three parts: (a) a general discussion of sex-related differences pertaining to math and science students; (b) the effect of one's preparation on academic performance; and (c) the effect of attitudes on academic performance.

A General Discussion of Sex-Related Differences Pertaining to Math and Science Students

General Information

Many more men than women appear to be attracted to the physical sciences. A greater percentage of men than women receive physics degrees. In 1978-79, the percentages of women awarded the bachelors degree, the masters degree, and the doctorate were 11, 10, and 6 respectively (AIP Report, 1980). The percentage of women who have been awarded the bachelors degree in physics has only slightly increased over the years. Also, the percentage of women in study at the graduate level has not changed much. In

1976-77, 10.5% of the bachelors degrees were awarded to women (AIP Report, 1978), and by 1979, 12.8% were awarded to women (AIP Report, 1980). The percentage had increased to only 11.3% by 1983 (AIP Report, 1984). If advanced study is considered, the percentage of women also remains quite unchanged. The percentages of women in graduate study in 1976-77, 1977-78, and 1978-79 were 9%, 9%, and 8% respectively (AIP Report, 1978; AIP Report, 1979; and AIP Report, 1980). In 1982-83, 11% of those in graduate study were women (AIP Report, 1984).

Beyond the doctorate, women continue to drop out. The umemployment rate among females who hold doctorates was about 5% as compared to less than 1% among males in 1979 to 1980 (Yearbook of Higher Education, 1979). According to Vetter and Babco (1984), while most college teachers in foreign language, English, home economics, and the health specialties are female, less than 5% in physics and engineering are women.

Heredity

Why do more men than women study physics? One's ability for, preparation for, and attitudes toward physics can affect success in physics. Although this study did not investigate one's innate ability to do physics, there is evidence that heredity might play a part. For example,

Stafford (1961) suggests that sex differences in ability may occur in a recessive gene located on the X chromosome. Stafford explains that if a gene were sex-linked and recessive, then it could show up more often in males than in females since males have a Y chromosome and only one X chromosome, while females have two X chromosomes. A male would only have to receive one recessive gene located on the X chromosome in order to receive innate mathematical ability, while females would have to receive two such recessive genes if they were to receive an innate ability for math. How would this gene manifest itself? Five research investigations studied this phenomenon. Research by Salkind (1976) supports the claim that boys do better than girls on spatial visualization tests. Bock and Kolakowski (1973) state that parents and offspring exhibit an ability for spatial visualization which matches the pattern expected for a sex-linked recessive gene. Sex differences may be displayed through adrenergic activating and cholinergic inhibitory neural responses (Broverman, Klaiber, Kobayashi, and Vogel, 1968). Adrenergic and cholinergic systems are competitive. One system activates the neuron to fire, while the other system inhibits such firing. The authors just mentioned suggest that these systems are sensitive to sex hormones. Further, the authors hypothesize that alterations of the balance of these two systems affects one's cognitive abilities: an

increase in the adrenergic activating system relative to the cholinergic inhibitory system would inhibit one's ability for perceptual restructuring and facilitate one's perceptual-motor ability.

Sex-related neural effects were observed in eyelid conditioning experiments (Spence and Spence, 1966). It is interesting that anxiety was also found to be related to neural effects. Witelson (1976) suggests that sex differences in the neural organization of the right and left brain may affect cognitive development. According to Witelson, males can be found to display such right brain socialization by age 13. Kilshaw and Annett (1983) give evidence for superior skill shown in left-handers. A group varying in age from 3 1/2 years to over 50 years was studied. The group was asked to move pegs with their right and left hands. In practically all age groups males were faster than females with their left hands. Females were generally faster with their right hands until 10 years of age. After ten, males equaled and later surpassed females in most of the older groups. Also, left-handers were faster than right-handers; right-mixed-handers were intermediate in speed for moving pegs with the non-preferred hand. The conclusion of this article was that the left hemisphere specialization for language may be achieved by way of a right hemisphere handicap and left

handers may be advantaged in that they may have escaped this risk. Thus, left-handers may have a better mathematical abilty as compared tto right-handers.

Benbow and Stanley (1980) suggest that sex differences in math achievement may stem from a greater male aptitude for mathematics. They base this premise on data compiled over eight years by the Study of Mathematically Precocious Youth. Approximately 10,000 males and females took part in the study. They found, for example, that of those scoring above 500 on the Scholastic Aptitude Test in Mathematics, males outnumbered females in a ratio greater than 2 to 1. Thus, heredity may influence one's ability to do physics.

Culture

In addition to hereditary factors, cultural factors may also account for sex differences. Cultural factors are environmental influences. For example, women may choose not to study physics because they are convinced that physics is inappropriate for females. Children may learn at a very early age what behavior is considered sexually appropriate for them. The kinds of toys which parents select for their children may indicate the cultural appropriateness of certain role behaviors (Rheingold and Cook, 1975). In 1972 and 1973, Rheingold and Cook studied

the rooms of 48 boys and 48 girls, all under the age of six. The names of the children were primarily obtained from birth censuses at North Carolina Memorial Hospital. The researchers found that boys were given a greater number of vehicles, sports equipment, toy animals, depots, fauna, machines, military toys, and educational art. Girls were given a greater number of doll houses, dolls, and domestic toys. These toys may suggest the kinds of interests which children are expected to manifest as they mature. In addition, certain out-of class experiences might contribute to an appearant male superiority in math (Tomizuka and Tobias, 1981). These authors suggest that males may learn certain math skills by participating in such sports as sailing or such games as billiards. Thus, children's behaviors may be modified by cultural pressures.

If cultural factors have significantly deterred women from this field, then perhaps something can be done. Females should be as strongly encouraged as males to excell in math and science. Perhaps, if females are strongly encouraged to engage in more math and science related activities, they will acquire preparation better suited for advanced study in physics. Also, such encouragement may convince women that physics can be an appropriate field for them. It was once thought that sports were for men. World records in sports show women to be approaching men: this rate of approach has increased in

later years (Dyer, 1984). Dyer cites in an article entittled "Catching Up the Men" that while a decade ago women ran 75% as fast as men, top female athletes today are close to 90% the speed of men. Since sports have become acceptable for women, women have become better at sports. If women are convinced that math and science are appropriate fields for women, then perhaps they will be as succesful as men.

Males may develop skills different from those of females. Is spatial visualization hereditary, or is it a skill which is acquired? As Kistiakowsky (1980) states, even if spatial ability is inherited, it may mean only that one of many genes responsible for math performance is sex-linked, and a learned component for the use of these abilities would also influence one's achievement in that subject. Kistiakowsky, as well as Fennema (1979), suggests that educational programs might be planned to better develop this skill. Patricia Blatter (1982) wrote an article that discussed some previous reports on spatial ability. According to the article, the data are conflicting, and, as the author concludes, the environment as well as genetic factors have not been thoroughly researched.

The Effect of Preparation on Academic Performance in Math and Science

General Discussion of Math and Science Preparation for Physics

In general, the math and science preparation of female students appears to be poor compared to that of male students. Haven (1970) found that females were much less likely than males to take math and science in high school. In collaboration with specialists from the Educational Testing Service, a questionnaire was distributed in 1966 to more than 26,000 students. While 84% of the males were found to have studied math during their senior year, only 56% of the females did so. Also, 82% of the males reported that they studied science, while only 60% of the females said the same.

Innate ability does not appear to be the only factor which determines the choice to study a mathematical field. A study by Deboer (1984) found women to take less science and math both in high school and college than males although they performed better than the males. A random sample of 30% of graduates from a liberal arts college during the years 1975, 1977, and 1979 were selected. Although females had a GPA of 3.40 as opposed to a GPA of 3.18 for males in high school science, they took only 3.13

years of science as opposed to 3.46 years for males. Also, while females received a GPA of 3.36 as opposed to 3.10 for males in high school math, females took only 3.51 years of this subject as opposed to 3.77 years for males. In college science women had a GPA of 2.86 as opposed to 2.76 for men, although females took only 2.21 years as opposed to 3.38 years for males. In college math, females had a GPA of 2.80 as opposed to 2.58 for males, although women took only 0.76 years of the subject as opposed to 1.05 years for men.

Mathematics Preparation For Physics

A deficient background in math affects one's performance in physics because physics is generally taught as a mathematically based discipline. The solutions of most physics related problems rely on one's ability to work with numbers. Consequently, it is reasonable to suggest that an individual's background in mathematics is very important for one's performance in the field. Brasted (1957) obtained data from 1400 students who took part in a study begun by the High School Liaison Committee of the Minnesota Section of the American Chemical Society. He also collected information from 1100 more students in a supplementary survey. Students who were enrolled in first quarter college chemistry courses designed for academic